PATENT ABSTRACTS OF JAPAN

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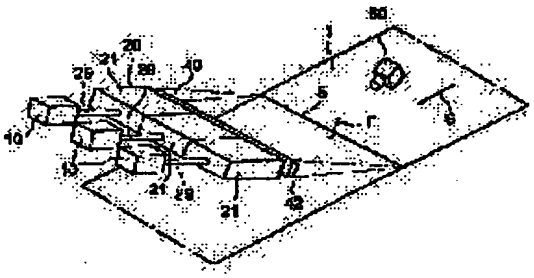
(54) LIGHTING SYSTEM FOR INSPECTING FLAW

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a lighting system for inspecting flaws wherein a surface of a material to be inspected is evenly irradiated and flaws can be detected with a high detecting performance.
SOLUTION: A plurality of optical fibers 26 comprises plural optical fiber bundles 22 which are aligned in a vertical direction with respect to an optical axis of the optical fibers 26. The system includes an optical fiber unit 21 connected so that the optical fiber bundles may line up along such alignment direction, and a light-gathering unit 40 connected so that a plurality of condenser lenses 42 comprising cylindrical lenses may form a line along the alignment direction of the optical fibers 26. The light-gathering unit 40 is placed at a light emitting side of the optical fiber unit 21 so that a connecting portion of the condenser lenses 42 may deviate in the alignment direction of the optical fibers 26 with respect to a connecting portion of the optical fiber bundles 22.



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CLAIMS

[Claim(s)]

[Claim 1] In the crack checking lighting system which forms a linear exposure pattern in the front face of band-like or tabular inspected material The optical fiber unit joined so that many optical fibers might consist of two or more optical fiber bundles which align perpendicularly to the optical axis of an optical fiber and an optical fiber bundle might be located in a line along said alignment direction, It has the beam condensing unit joined so that two or more condenser lenses which consist of a cylindrical lens might be located in a line along the alignment direction of said optical fiber. The crack checking lighting system characterized by arranging the beam condensing unit at the outgoing radiation side of said optical fiber unit as the joint of a condenser lens shifts in the alignment direction of said optical fiber to the joint of said optical fiber bundle.

[Claim 2] In the crack checking lighting system which forms a linear exposure pattern in the front face of band-like or tabular inspected material The optical fiber unit joined so that many optical fibers might consist of two or more optical fiber bundles which align perpendicularly to the optical axis of an optical fiber and an optical fiber bundle might be located in a line along said alignment direction, The crack checking lighting system characterized by the diameter of said condenser lens which is equipped with the beam condensing unit joined so that two or more condenser lenses which consist of a cylindrical lens might be located in a line along the alignment direction of said optical fiber, and counters the side edge section of said optical fiber bundle being larger than the diameter of the condenser lens of a center section.

[Claim 3] In the crack checking lighting system which forms a linear exposure pattern in the front face of band-like or tabular inspected material The optical fiber unit joined so that many optical fibers might consist of two or more optical fiber bundles which align perpendicularly to the optical axis of an optical fiber and an optical fiber bundle might be located in a line along said alignment direction, The crack checking lighting system which is equipped with the beam condensing unit joined so that two or more condenser lenses which consist of a cylindrical lens might be located in a line along the alignment direction of said optical fiber, and is characterized by the diameter of an optical fiber of the side edge section of said optical fiber bundle being larger than the diameter of an optical fiber of a center section.

[Claim 4] Claims 1 and 2 between which the optical fiber put said optical fiber unit accumulated on two or more steps by the superior lamella and inferior lamella which have rigidity, or a crack checking lighting system given in three.

[Claim 5] The crack checking lighting system according to claim 4 with which the parallel guide rail of a large number in which one optical fiber is inserted at a time is prepared in said inferior lamella.

[Claim 6] It doubles with bending of said optical fiber unit, and they are ********** claims 1 and 2 or a crack checking lighting system given in three about said beam condensing unit.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to a crack checking lighting system, especially the crack checking lighting system which illuminates the front face of band-like or tabular inspected material, and inspects a crack optically.
[0002]
[Description of the Prior Art] There is optical crack test equipment as one of band-like or the crack test equipment of a plate. Optical crack test equipment is equipped with the lighting system which forms a linear lighting pattern in the front face of inspected material. For example, a linear lighting pattern with delivery is formed in a steel plate front face for a steel plate at a longitudinal direction, and an inspection operator views a steel plate front face directly, or a crack is inspected on monitor display.
[0003] Conventionally, the cylindrical light source of the lighting system which makes a fluorescent lamp representation was very inadequate in the quantity of light and condensing nature. it being weak to about [that distance with inspected material moreover cannot be taken] and a temperature change, and there being no directivity, and constituting the long (for example, 2m) cylindrical light source — difficult — application to high-speed Rhine, and an image pick-up — resolution was not able to be raised. As a lighting system which solves such a problem, optical fiber lighting is expected and various optical fiber lighting systems are developed.
[0004] The optical fiber lighting system consists of the light source, an optical fiber bundle of the shape of a sheet in which a large number carry out optical fiber alignment, and a condenser lens that forms a linear exposure pattern in the front face of band-like or tabular inspected material. Although the conventional optical fiber lighting system combined a commercial optical fiber bundle and a commercial condenser lens (cylindrical lens), it had the following problems.
[0005] Since the optical fiber bundle which aligns for a long time crosswise (it is perpendicularly to an optical fiber optical axis) according to the width of face of inspected material was needed, some of optical fiber bundles 24 with a width of face of about 500mm had been joined crosswise. The illuminance had deteriorated in this joint. Since the optical fiber 26 had not necessarily aligned regularly at the both ends of an optical fiber bundle 24 as shown in drawing 11 , illuminance degradation had been caused. Moreover, although a condenser lens also has a limit in die length and had joined two or more condensing cylindrical lenses with ultraviolet-rays hardening resin etc., illuminance degradation had arisen in the joint. Moreover, although two or more steps of optical fibers are accumulated in the optical fiber bundle, since the superior lamella 55 and inferior lamella 56 which are held optical fiber unit 21 bend as shown in drawing 12 and drawing 13 , the center section of the optical fiber bundle 22 is dented to the order which is about 100 micrometers, or it swells up. For these depressions or bulging, the beam of light of the illumination light becomes irregular. If the distance of a condenser lens 40 and inspected material is set to about several m, as shown in drawing 14 R> 4, it will become irregular to about several mm order by inspected material. Consequently, the illuminance on the front face of inspected material became uneven, and crack detectivity was falling.

[0006] In addition, there is surface-analysis equipment indicated by JP,2000-65755,A as a lighting system using the cylindrical light source. As a lighting system equipped with the optical fiber bundle and the condenser lens, there is a lighting system indicated by JP,2000-149607,A.
[0007]
[Problem(s) to be Solved by the Invention] The technical problem of this invention is offering the crack checking lighting system which irradiates an inspected material front face at homogeneity, and can detect a crack by high crack detectivity.
[0008]
[Means for Solving the Problem] In the crack checking lighting system which forms a linear exposure pattern in the front face of band-like or tabular inspected material, many optical fibers consisted of two or more optical fiber bundles which align perpendicularly to the optical axis of an optical fiber, and the crack checking lighting system of the 1st invention is equipped with the optical fiber unit joined so that an optical fiber bundle might be located in a line along said alignment direction, and the beam condensing unit joined so that two or more condenser lenses which consist of a cylindrical lens might be located in a line along the alignment direction of said optical fiber. And as the joint of a condenser lens shifts in the alignment direction of said optical fiber to the joint of said optical fiber bundle, the beam condensing unit is arranged at the outgoing radiation side of said optical fiber unit.
[0009] In the above-mentioned crack checking lighting system, the joint of a condenser lens is located so that it may shift in the alignment direction (longitudinal direction) of an optical fiber to the joint of an optical fiber bundle. Therefore, the illuminance fall by the lap of the joint of an optical fiber bundle and the joint of a condenser lens is not produced.
[0010] In the crack checking lighting system which forms a linear exposure pattern in the front face of band-like or tabular inspected material, many optical fibers consisted of two or more optical fiber bundles which align perpendicularly to the optical axis of an optical fiber, and the crack checking lighting system of the 2nd invention is equipped with the optical fiber unit joined so that an optical fiber bundle might be located in a line along said alignment direction, and the beam condensing unit joined so that two or more condenser lenses which consist of a cylindrical lens might be located in a line along the alignment direction of said optical fiber. And the diameter of said condenser lens which counters the side edge section of said optical fiber bundle is larger than the diameter of the condenser lens of a center section.
[0011] In the above-mentioned crack checking lighting system, when outgoing radiation is carried out so that a beam of light may spread from the side edge section of an optical fiber bundle, the condenser lens of said major diameter can bring the spreading beam of light together in an inspected material front face, and can prevent an illuminance fall.
[0012] In the crack checking lighting system which forms a linear exposure pattern in the front face of band-like or tabular inspected material, many optical fibers consisted of two or more optical fiber bundles which align perpendicularly to the optical axis of an optical fiber, and the crack checking lighting system of the 3rd invention is equipped with the optical fiber unit joined so that an optical fiber bundle might be located in a line along said alignment direction, and the beam condensing unit joined so that two or more condenser lenses which consist of a cylindrical lens might be stood in a line along the alignment direction of said optical fiber. And the diameter of an optical fiber of the side edge section of said optical fiber bundle is larger than the diameter of an optical fiber of a center section.
[0013] Since there is much quantity of light irradiated from the outlet side of an optical fiber when the diameter of an optical fiber is large, even if the non-set of some optical fibers has arisen, the illuminance fall concerned which originates irregularly can be prevented.
[0014] In the above 1st and invention of 2 and 3, it is desirable to put the optical fiber accumulated on two or more steps by said optical fiber unit by the superior lamella and inferior lamella which have rigidity. Since bending of an optical fiber unit is corrected by ****** by the superior lamella and inferior lamella which have rigidity, a straight-line-like lighting pattern is formed on inspected material. It is desirable to prepare the parallel guide rail of a large number in which one optical fiber is inserted at a time in said inferior lamella. Since the optical fiber of the bottom aligns along with a guide rail and sequential sorting of the optical fiber of an upper case is

carried out along with the optical fiber of the bottom, an optical fiber does not become irregular.
[0015] Moreover, you may make it sag said beam condensing unit in the above 1st and invention of 2 and 3 according to bending of said optical fiber unit. By adjusting bending of a condenser lens, the irregular beam of light from an optical fiber bundle can be aligned in parallel.
[0016]
[Embodiment of the Invention] Drawing 1 , drawing 2 , and drawing 3 show the lighting system of the 1st invention typically. The lighting system mainly consists of the light source, the light guide section, and the condensing section.
[0017] The light source 10 is equipped with the high brightness point light source 12 and a concave mirror 14. A metal halide lamp, a halogen lamp, a xenon lamp, etc. are used as the high brightness point light source 12. The ellipsoid mirror or the parabolic mirror is suitable as a concave mirror 14.
[0018] The light guide section 20 is equipped with the fiber optic cable 29 prolonged from the light source 10 to an optical fiber unit 21. Many optical fibers 26 are bundled and the fiber optic cable 29 is covered with the plastics sheath. In the interior of an optical fiber unit 21, an optical fiber 26 carries out branching alignment from the point of a fiber optic cable 29, and constitutes an optical fiber bundle 22 (shown in drawing 3). An optical fiber bundle 22 aligns perpendicularly (longitudinal direction) to an optical axis, it is accumulated two or more steps and many optical fibers 26 are constituted. Optical fiber bundle 22 which adjoin a longitudinal direction have band-like [to which the side edge section is tied by adhesives according to the width of face of inspected material 1, and extends in a longitudinal direction]. An optical fiber unit 21 is inserted between a superior lamella 31 and an inferior lamella 32, and is held at the optical fiber maintenance frame 30.
[0019] The condensing section 40 is equipped with the beam condensing unit 41 which consists of two or more condenser lenses 42. A cylindrical lens is used as a condenser lens 42. The side edge section is tied by adhesives like an optical fiber bundle 22, and condenser lens 42 which adjoin a longitudinal direction have become a longitudinal direction with ** length. The joint 43 of a condenser lens 42 is located so that it may shift to a longitudinal direction to the joint 23 of an optical fiber bundle 22. It is made, as for this gap, for the joint of a lens to be located in the pars intermedia of each optical fiber. Therefore, the illuminance fall by the lap of the joint 23 of an optical fiber bundle 22 and the joint 43 of a condenser lens 42 is not produced.
[0020] In the equipment constituted as mentioned above, the illumination light from the high brightness point light source 12 is condensed by the incidence edge of a fiber optic cable 29 with a concave mirror 14. The illumination light is led to an optical fiber unit 21 through a fiber optic cable 29. It is condensed with a condenser lens 42 and the illumination light which carried out outgoing radiation through the optical fiber unit 21 forms the linear lighting pattern 5 in the inspected body surface 1. The inspected object 1 is moving to the longitudinal direction S of this, and Crack F is picturized with the linear array camera 60. On the screen of a monitor (not shown), Crack F carries out the image processing of viewing or the video signal, and is detected. The illuminance fall by the lap of the joint 23 of an optical fiber bundle 22 and the joint 43 of a condenser lens 42 is not produced. For this reason, an inspected material front face is irradiated at homogeneity, and high crack detectivity can detect a crack.
[0021] Drawing 4 and drawing 5 show the lighting system of the 2nd invention. The same reference mark is attached to the member shown in drawing 1 , and the same member, and the detailed explanation is omitted. The beam condensing unit 45 consists of a standard condenser lens 47 and a major-diameter condenser lens 48. The focal distance is equal to the focal distance of the standard condenser lens 47 by making the diameter of the major-diameter condenser lens 48 into about 1.5 to 2.0 times of the diameter of the standard condenser lens 47, and setting the lens quality of the material to nd=1.8-1.9. Here, nd shows the refractive index at the time of measuring a refractive index using the light (wavelength being 587.6 [nm]) emitted from a helium lamp. The major-diameter condenser lens 48 is in the location which counters the joint 23 of an optical fiber bundle 22. As mentioned above, the actual optical fiber bundle 24 is drawing 11 . The optical fiber 26 of the side edge section has not aligned so that it may be shown. For this reason, since outgoing radiation of the beam of light from an optical fiber unit 21

is carried out so that it may spread, an illuminance falls in inspected material. The above-mentioned major-diameter condenser lens 48 can bring together the beam of light which spread in the side edge section of an optical fiber bundle 24 in an inspected material front face, and can prevent an illuminance fall.

[0022] Drawing 6 shows the lighting system of the 3rd invention. The same reference mark is attached to the member shown in drawing 1 , and the same member, and the detailed explanation is omitted. At the both-sides edge of an optical fiber bundle 25, the optical fiber 26 (optical fiber of a center section) of the diameter of a criterion and the larger major-diameter optical fiber 27 than the diameter of a criterion are put together. If the train of an optical fiber 26 is confused in the side edge section of an optical fiber bundle 25 like drawing 11 , an illuminance fall will be caused, but with the equipment shown in drawing 6 , even if the non-set of some optical fibers has arisen since the diameter of an optical fiber 27 is large, and there is much quantity of light irradiated from the outlet side of an optical fiber, the illuminance fall concerned which originates irregularly can be prevented. The width of face of full [of an optical fiber bundle 25 / about 10 - 20% therefore of] and a center section of the width of face of the side edge section is 60 - 80%. The diameter of the optical fiber 27 of the side edge section is about 2 to 3 times of the diameter of the standard optical fiber 26 of a center section. It may be made to make the diameter of an optical fiber small gradually as it is good only also as a major-diameter optical fiber and the optical fiber of the side edge section is gone to a center section from the side edge section.

[0023] Drawing 7 shows the gestalt of other operations of a lighting system. The optical fiber unit 21 is held between the superior lamellas 31 and inferior lamellas 32 which have rigidity within the optical fiber maintenance frame 30. It is acceptable optical fiber maintenance frame 30, an adjusting screw 37 inserts each other in a thread part 36, and the tip of an adjusting screw 37 is pressed against the superior lamella 31 and the inferior lamella 32, respectively. Since an adjusting screw 37 is bound tight according to bending of an optical fiber unit 31 and bending of an optical fiber unit 21 is corrected, a straight-line-like lighting pattern is formed on inspected material.

[0024] Drawing 8 shows the gestalt of further others of a lighting system. In this lighting system, the parallel semicircle-like guide rail 34 is formed in the inferior lamella 33 of said optical fiber maintenance frame along the direction of an optical axis of an optical fiber. The diameter of a guide rail 34 is about 100-300 micrometers. One optical fiber is inserted in a guide rail 34 at a time, and the optical fiber 26 from the 2nd step is accumulated on it. As shown in drawing 9 , the optical fiber 26 of an upper case is arranged between the optical fibers 26 with which the lower berth adjoins each other. Since an optical fiber 26 aligns along with the optical fiber 26 of the bottom, it does not become irregular [an optical fiber 26] in the side edge section of an optical fiber bundle 22.

[0025] Drawing 10 shows the gestalt of the operation of further others of a lighting system. Drawing 10 (a) The beam condensing unit 49 is held at the lens maintenance frame 50 so that it may be shown. The adjusting screw 52 inserts each other in the nut 51 attached in the lens maintenance frame 50. The point of an adjusting screw 52 is pressed against the condenser lens 49, and doubles bending of a condenser lens 49 with bending of an optical fiber bundle with an adjusting screw 52. By adjusting bending of a condenser lens, the irregular beam of light from an optical fiber bundle can be aligned in parallel. Drawing 10 (b) The lighting pattern on an inspected material front face is shown, and the beam-of-light locus 8 which curved by adjusting bending of a condenser lens 49 can be corrected to the norm straight line 7.

[0026]

[Effect of the Invention] In the crack checking lighting system of the 1st invention, since the joint of a condenser lens is located so that it may shift to a longitudinal direction to the joint of an optical fiber bundle, the illuminance fall by the lap of the joint of an optical fiber bundle and the joint of a condenser lens is not produced. With the crack checking lighting system of the 2nd invention, the diameter of a condenser lens of the both ends of an optical fiber bundle is larger than the diameter of a condenser lens of a center section, and with the crack checking lighting system of the 3rd invention, since the diameter of an optical fiber of the both ends of an optical

fiber bundle is larger than the diameter of an optical fiber of a center section, the non-set of the beam of light in the side edge section of an optical fiber bundle can be prevented. These results, an inspected material front face is irradiated by homogeneity and can detect a crack by high crack detectivity.

[Translation done.]

PRIOR ART

[Description of the Prior Art] There is optical crack test equipment as one of band-like or the crack test equipment of a plate. Optical crack test equipment is equipped with the lighting system which forms a linear lighting pattern in the front face of inspected material. For example, a linear lighting pattern with delivery is formed in a steel plate front face for a steel plate at a longitudinal direction, and an inspection operator views a steel plate front face directly, or a crack is inspected on monitor display.

[0003] Conventionally, the cylindrical light source of the lighting system which makes a fluorescent lamp representation was very inadequate in the quantity of light and condensing nature. it being weak to about [that distance with inspected material moreover cannot be taken] and a temperature change, and there being no directivity, and constituting the long (for example, 2m) cylindrical light source — difficult — application to high-speed Rhine, and an image pick-up — resolution was not able to be raised. As a lighting system which solves such a problem, optical fiber lighting is expected and various optical fiber lighting systems are developed.

[0004] The optical fiber lighting system consists of the light source, an optical fiber bundle of the shape of a sheet in which a large number carry out optical fiber alignment, and a condenser lens that forms a linear exposure pattern in the front face of band-like or tabular inspected material. Although the conventional optical fiber lighting system combined a commercial optical fiber bundle and a commercial condenser lens (cylindrical lens), it had the following problems.

[0005] Since the optical fiber bundle which aligns for a long time crosswise (it is perpendicularly to an optical fiber optical axis) according to the width of face of inspected material was needed, some of optical fiber bundles 24 with a width of face of about 500mm had been joined crosswise. The illuminance had deteriorated in this joint. Since the optical fiber 26 had not necessarily aligned regularly at the both ends of an optical fiber bundle 24 as shown in drawing 11 , illuminance degradation had been caused. Moreover, although a condenser lens also has a limit in die length and had joined two or more condensing cylindrical lenses with ultraviolet-rays hardening resin etc., illuminance degradation had arisen in the joint. Moreover, although two or more steps of optical fibers are accumulated in the optical fiber bundle, since the superior lamella 55 and inferior lamella 56 which are held optical fiber unit 21 bend as shown in drawing 12 and drawing 13 , the center section of the optical fiber bundle 22 is dented to the order which is about 100 micrometers, or it swells up. For these depressions or bulging, the beam of light of the illumination light becomes irregular. If the distance of a condenser lens 40 and inspected material is set to about several m, as shown in drawing 14 R> 4, it will become irregular to about several mm order by inspected material. Consequently, the illuminance on the front face of inspected material became uneven, and crack detectivity was falling.

[0006] In addition, there is surface-analysis equipment indicated by JP,2000-65755,A as a lighting system using the cylindrical light source. As a lighting system equipped with the optical fiber bundle and the condenser lens, there is a lighting system indicated by JP,2000-149607,A.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] In the crack checking lighting system of the 1st invention, since the joint of a condenser lens is located so that it may shift to a longitudinal direction to the joint of an optical fiber bundle, the illuminance fall by the lap of the joint of an optical fiber bundle and the joint of a condenser lens is not produced. With the crack checking lighting system of the 2nd invention, the diameter of a condenser lens of the both ends of an optical fiber bundle is larger than the diameter of a condenser lens of a center section, and with the crack checking lighting system of the 3rd invention, since the diameter of an optical fiber of the both ends of an optical fiber bundle is larger than the diameter of an optical fiber of a center section, the non-set of the beam of light in the side edge section of an optical fiber bundle can be prevented. These results, an inspected material front face is irradiated by homogeneity and can detect a crack by high crack detectivity.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] The technical problem of this invention is offering the crack checking lighting system which irradiates an inspected material front face at homogeneity, and can detect a crack by high crack detectivity.

[Translation done.]

MEANS

[Means for Solving the Problem] In the crack checking lighting system which forms a linear exposure pattern in the front face of band-like or tabular inspected material, many optical fibers consisted of two or more optical fiber bundles which align perpendicularly to the optical axis of an optical fiber, and the crack checking lighting system of the 1st invention is equipped with the optical fiber unit joined so that an optical fiber bundle might be located in a line along said alignment direction, and the beam condensing unit joined so that two or more condenser lenses which consist of a cylindrical lens might be located in a line along the alignment direction of said optical fiber. And as the joint of a condenser lens shifts in the alignment direction of said optical fiber to the joint of said optical fiber bundle, the beam condensing unit is arranged at the outgoing radiation side of said optical fiber unit.
[0009] In the above-mentioned crack checking lighting system, the joint of a condenser lens is located so that it may shift in the alignment direction (longitudinal direction) of an optical fiber to the joint of an optical fiber bundle. Therefore, the illuminance fall by the lap of the joint of an optical fiber bundle and the joint of a condenser lens is not produced.
[0010] In the crack checking lighting system which forms a linear exposure pattern in the front face of band-like or tabular inspected material, many optical fibers consisted of two or more optical fiber bundles which align perpendicularly to the optical axis of an optical fiber, and the crack checking lighting system of the 2nd invention is equipped with the optical fiber unit joined so that an optical fiber bundle might be located in a line along said alignment direction, and the beam condensing unit joined so that two or more condenser lenses which consist of a cylindrical lens might be located in a line along the alignment direction of said optical fiber. And the diameter of said condenser lens which counters the side edge section of said optical fiber bundle is larger than the diameter of the condenser lens of a center section.
[0011] In the above-mentioned crack checking lighting system, when outgoing radiation is carried out so that a beam of light may spread from the side edge section of an optical fiber bundle, the condenser lens of said major diameter can bring the spreading beam of light together in an inspected material front face, and can prevent an illuminance fall.
[0012] In the crack checking lighting system which forms a linear exposure pattern in the front face of band-like or tabular inspected material, many optical fibers consisted of two or more optical fiber bundles which align perpendicularly to the optical axis of an optical fiber, and the crack checking lighting system of the 3rd invention is equipped with the optical fiber unit joined so that an optical fiber bundle might be located in a line along said alignment direction, and the beam condensing unit joined so that two or more condenser lenses which consist of a cylindrical lens might be stood in a line along the alignment direction of said optical fiber. And the diameter of an optical fiber of the side edge section of said optical fiber bundle is larger than the diameter of an optical fiber of a center section.
[0013] Since there is much quantity of light irradiated from the outlet side of an optical fiber when the diameter of an optical fiber is large, even if the non-set of some optical fibers has arisen, the illuminance fall concerned which originates irregularly can be prevented.
[0014] In the above 1st and invention of 2 and 3, it is desirable to put the optical fiber accumulated on two or more steps by said optical fiber unit by the superior lamella and inferior

lamella which have rigidity. Since bending of an optical fiber unit is corrected by ****** by the superior lamella and inferior lamella which have rigidity, a straight-line-like lighting pattern is formed on inspected material. It is desirable to prepare the parallel guide rail of a large number in which one optical fiber is inserted at a time in said inferior lamella. Since the optical fiber of the bottom aligns along with a guide rail and sequential sorting of the optical fiber of an upper case is carried out along with the optical fiber of the bottom, an optical fiber does not become irregular.
[0015] Moreover, you may make it sag said beam condensing unit in the above 1st and invention of 2 and 3 according to bending of said optical fiber unit. By adjusting bending of a condenser lens, the irregular beam of light from an optical fiber bundle can be aligned in parallel.
[0016]
[Embodiment of the Invention] Drawing 1 , drawing 2 , and drawing 3 show the lighting system of the 1st invention typically. The lighting system mainly consists of the light source, the light guide section, and the condensing section.
[0017] The light source 10 is equipped with the high brightness point light source 12 and a concave mirror 14. A metal halide lamp, a halogen lamp, a xenon lamp, etc. are used as the high brightness point light source 12. The ellipsoid mirror or the parabolic mirror is suitable as a concave mirror 14.
[0018] The light guide section 20 is equipped with the fiber optic cable 29 prolonged from the light source 10 to an optical fiber unit 21. Many optical fibers 26 are bundled and the fiber optic cable 29 is covered with the plastics sheath. In the interior of an optical fiber unit 21, an optical fiber 26 carries out branching alignment from the point of a fiber optic cable 29, and constitutes an optical fiber bundle 22 (shown in drawing 3). An optical fiber bundle 22 aligns perpendicularly (longitudinal direction) to an optical axis, it is accumulated two or more steps and many optical fibers 26 are constituted. Optical fiber bundle 22 which adjoin a longitudinal direction have band-like [to which the side edge section is tied by adhesives according to the width of face of inspected material 1, and extends in a longitudinal direction]. An optical fiber unit 21 is inserted between a superior lamella 31 and an inferior lamella 32, and is held at the optical fiber maintenance frame 30.
[0019] The condensing section 40 is equipped with the beam condensing unit 41 which consists of two or more condenser lenses 42. A cylindrical lens is used as a condenser lens 42. The side edge section is tied by adhesives like an optical fiber bundle 22, and condenser lens 42 which adjoin a longitudinal direction have become a longitudinal direction with ** length. The joint 43 of a condenser lens 42 is located so that it may shift to a longitudinal direction to the joint 23 of an optical fiber bundle 22. It is made, as for this gap, for the joint of a lens to be located in the pars intermedia of each optical fiber. Therefore, the illuminance fall by the lap of the joint 23 of an optical fiber bundle 22 and the joint 43 of a condenser lens 42 is not produced.
[0020] In the equipment constituted as mentioned above, the illumination light from the high brightness point light source 12 is condensed by the incidence edge of a fiber optic cable 29 with a concave mirror 14. The illumination light is led to an optical fiber unit 21 through a fiber optic cable 29. It is condensed with a condenser lens 42 and the illumination light which carried out outgoing radiation through the optical fiber unit 21 forms the linear lighting pattern 5 in the inspected body surface 1. The inspected object 1 is moving to the longitudinal direction S of this, and Crack F is picturized with the linear array camera 60. On the screen of a monitor (not shown), Crack F carries out the image processing of viewing or the video signal, and is detected. The illuminance fall by the lap of the joint 23 of an optical fiber bundle 22 and the joint 43 of a condenser lens 42 is not produced. For this reason, an inspected material front face is irradiated at homogeneity, and high crack detectivity can detect a crack.
[0021] Drawing 4 and drawing 5 show the lighting system of the 2nd invention. The same reference mark is attached to the member shown in drawing 1 , and the same member, and the detailed explanation is omitted. The beam condensing unit 45 consists of a standard condenser lens 47 and a major-diameter condenser lens 48. The focal distance is equal to the focal distance of the standard condenser lens 47 by making the diameter of the major-diameter condenser lens 48 into about 1.5 to 2.0 times of the diameter of the standard condenser lens 47, and setting the lens quality of the material to nd=1.8-1.9. Here, nd shows the refractive index at

the time of measuring a refractive index using the light (wavelength being 587.6 [nm]) emitted from a helium lamp. The major-diameter condenser lens 48 is in the location which counters the joint 23 of an optical fiber bundle 22. As mentioned above, the actual optical fiber bundle 24 is drawing 11 . The optical fiber 26 of the side edge section has not aligned so that it may be shown. For this reason, since outgoing radiation of the beam of light from an optical fiber unit 21 is carried out so that it may spread, an illuminance falls in inspected material. The above-mentioned major-diameter condenser lens 48 can bring together the beam of light which spread in the side edge section of an optical fiber bundle 24 in an inspected material front face, and can prevent an illuminance fall.

[0022] Drawing 6 shows the lighting system of the 3rd invention. The same reference mark is attached to the member shown in drawing 1 , and the same member, and the detailed explanation is omitted. At the both-sides edge of an optical fiber bundle 25, the optical fiber 26 (optical fiber of a center section) of the diameter of a criterion and the larger major-diameter optical fiber 27 than the diameter of a criterion are put together. If the train of an optical fiber 26 is confused in the side edge section of an optical fiber bundle 25 like drawing 11 , an illuminance fall will be caused, but with the equipment shown in drawing 6 , even if the non-set of some optical fibers has arisen since the diameter of an optical fiber 27 is large, and there is much quantity of light irradiated from the outlet side of an optical fiber, the illuminance fall concerned which originates irregularly can be prevented. The width of face of full [of an optical fiber bundle 25 / about 10 - 20% therefore of] and a center section of the width of face of the side edge section is 60 - 80%. The diameter of the optical fiber 27 of the side edge section is about 2 to 3 times of the diameter of the standard optical fiber 26 of a center section. It may be made to make the diameter of an optical fiber small gradually as it is good only also as a major-diameter optical fiber and the optical fiber of the side edge section is gone to a center section from the side edge section.

[0023] Drawing 7 shows the gestalt of other operations of a lighting system. The optical fiber unit 21 is held between the superior lamellas 31 and inferior lamellas 32 which have rigidity within the optical fiber maintenance frame 30. It is acceptable optical fiber maintenance frame 30, an adjusting screw 37 inserts each other in a thread part 36, and the tip of an adjusting screw 37 is pressed against the superior lamella 31 and the inferior lamella 32, respectively. Since an adjusting screw 37 is bound tight according to bending of an optical fiber unit 31 and bending of an optical fiber unit 21 is corrected, a straight-line-like lighting pattern is formed on inspected material.

[0024] Drawing 8 shows the gestalt of further others of a lighting system. In this lighting system, the parallel semicircle-like guide rail 34 is formed in the inferior lamella 33 of said optical fiber maintenance frame along the direction of an optical axis of an optical fiber. The diameter of a guide rail 34 is about 100-300 micrometers. One optical fiber is inserted in a guide rail 34 at a time, and the optical fiber 26 from the 2nd step is accumulated on it. As shown in drawing 9 , the optical fiber 26 of an upper case is arranged between the optical fibers 26 with which the lower berth adjoins each other. Since an optical fiber 26 aligns along with the optical fiber 26 of the bottom, it does not become irregular [an optical fiber 26] in the side edge section of an optical fiber bundle 22.

[0025] Drawing 10 shows the gestalt of the operation of further others of a lighting system. Drawing 10 (a) The beam condensing unit 49 is held at the lens maintenance frame 50 so that it may be shown. The adjusting screw 52 inserts each other in the nut 51 attached in the lens maintenance frame 50. The point of an adjusting screw 52 is pressed against the condenser lens 49, and doubles bending of a condenser lens 49 with bending of an optical fiber bundle with an adjusting screw 52. By adjusting bending of a condenser lens, the irregular beam of light from an optical fiber bundle can be aligned in parallel. Drawing 10 (b) The lighting pattern on an inspected material front face is shown, and the beam-of-light locus 8 which curved by adjusting bending of a condenser lens 49 can be corrected to the norm straight line 7.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the perspective view showing typically the crack checking lighting system which is the gestalt of implementation of the 1st invention.
[Drawing 2] It is the side elevation showing typically the optical system of the lighting system shown in drawing 1 .
[Drawing 3] Drawing 3 (a) It is the front view of the equipment shown in drawing 1 , and is (b). It is a top view.
[Drawing 4] The crack checking lighting system which is the gestalt of implementation of the 2nd invention is shown, and it is drawing 3 (a). It is a front view and is (b). It is a top view.
[Drawing 5] It is the side elevation of the beam condensing unit of the equipment shown in drawing 4 .
[Drawing 6] It is the gestalt of implementation of the 3rd invention and is the front view of an optical fiber bundle.
[Drawing 7] It is the front view showing the crack checking lighting system which are other gestalten of implementation of this invention.
[Drawing 8] It is the perspective view showing a part of inferior lamella used for the equipment shown in drawing 7 .
[Drawing 9] It is the front view of the optical fiber bundle held at the equipment shown in drawing 8 .
[Drawing 10] The crack checking lighting system which is the gestalt of further others of implementation of this invention is shown, and it is drawing 10 (a). It is a front view and is (b). It is the mimetic diagram of a lighting pattern.
[Drawing 11] It is the top view showing typically the non-set of the optical fiber in the side edge section of an optical fiber bundle.
[Drawing 12] It is the front view of the conventional crack checking lighting system showing one example typically.
[Drawing 13] It is the enlarged drawing of an optical fiber bundle shown in drawing 12 .
[Drawing 14] It is a drawing explaining the non-set of the beam of light of lighting.
[Description of Notations]
1 Inspected Material
5 Lighting Pattern
7 Norm Straight Line
8 Beam-of-Light Locus
10 Light Source
12 High Brightness Point Light Source
14 Concave Mirror
20 Light Guide Section
21 Optical Fiber Unit
22 25 Optical fiber bundle
23 Joint
26 27 Optical fiber

30 Optical Fiber Maintenance Frame
31 Superior Lamella
32 Inferior Lamella
33 Inferior Lamella
34 Guide Rail
37 Adjusting Screw
40 Condensing Section
41 Beam Condensing Unit
42 Condenser Lens
43 Joint
47 Standard Condenser Lens
48 Major-Diameter Condenser Lens
49 Condenser Lens
50 Condenser Lens Maintenance Frame
51 Nut 52
 Adjusting Screw
56 Superior Lamella
57 Inferior Lamella
F Crack

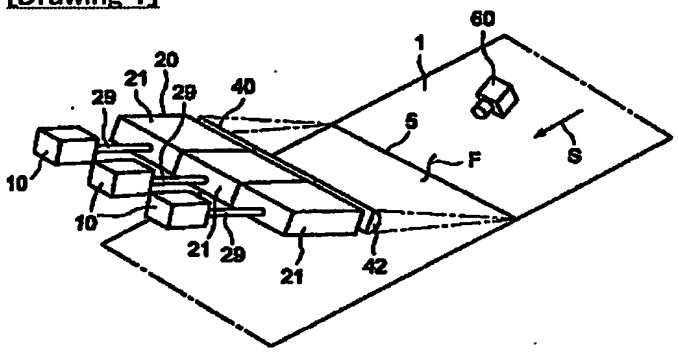
[Translation done.]

* NOTICES *

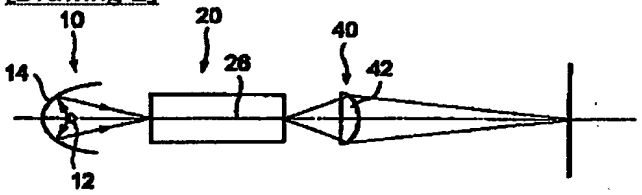
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

[Drawing 1]



[Drawing 2]



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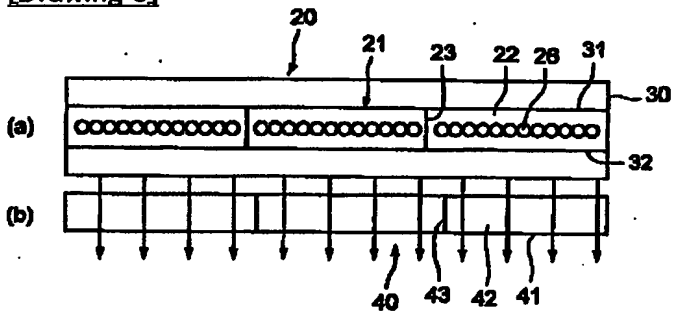

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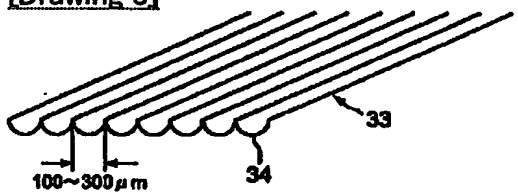
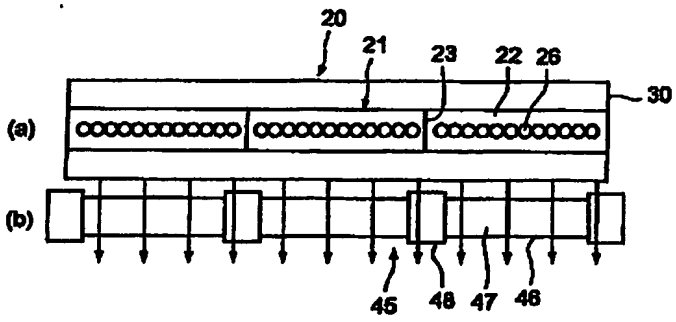
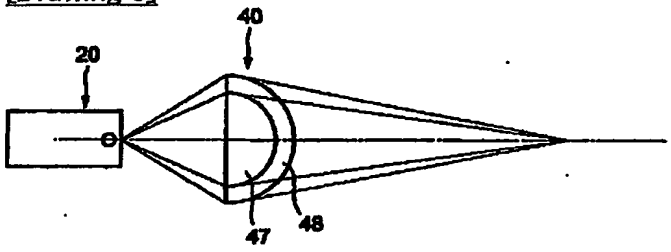


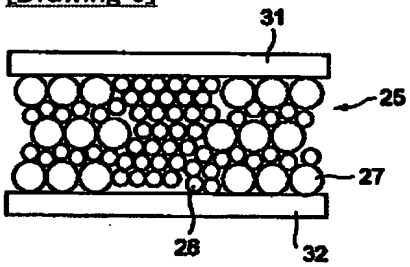
[Drawing 4]



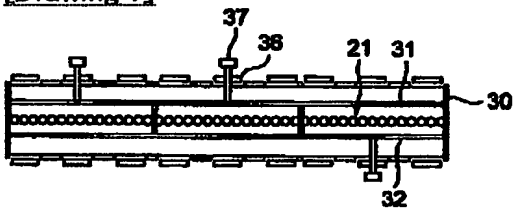
[Drawing 5]



[Drawing 6]



[Drawing 7]



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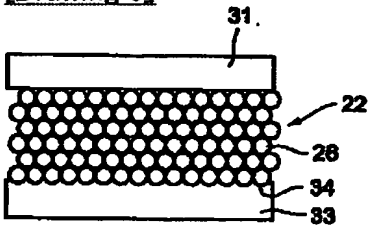

[Drawing 10]

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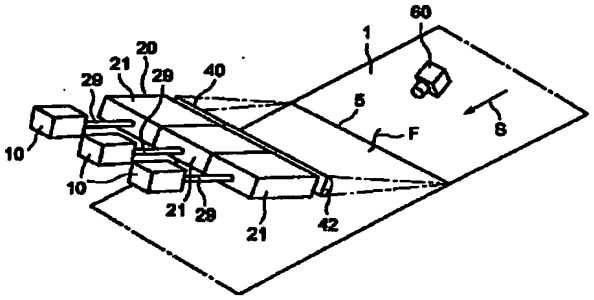
最終頁に続く

(54)【発明の名称】　疵検査用照明装置

(57)【要約】
【課題】　被検査材表面を均一に照射し、高い疵検出能により疵を検出することができる疵検査用照明装置を提供する。
【解決手段】　多数の光ファイバ２６が光ファイバ２６の光軸に対して垂直方向に整列する複数の光ファイバ束２２からなり、光ファイバ束が前記整列方向に沿って並ぶように接合された光ファイバユニット２１と、円柱レンズからなる複数の集光レンズ４２が前記光ファイバ２６の整列方向に沿って並ぶように接合された集光ユニット４０とを備え、前記光ファイバ束２２の接合部に対し集光レンズ４２の接合部が前記光ファイバ２６の整列方向にずれるようにして集光ユニット４０が前記光ファイバユニット２１の出射側に配置されている



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【特許請求の範囲】

【請求項１】　帯状または板状の被検査材の表面に線状の照射パターンを形成する疵検査用照明装置において、多数の光ファイバが光ファイバの光軸に対して垂直方向に整列する複数の光ファイバ束からなり、光ファイバ束が前記整列方向に沿って並ぶように接合された光ファイバユニットと、円柱レンズからなる複数の集光レンズが前記光ファイバの整列方向に沿って並ぶように接合された集光ユニットとを備え、前記光ファイバ束の接合部に対し集光レンズの接合部が前記光ファイバの整列方向にずれるようにして集光ユニットが前記光ファイバユニットの出射側に配置されていることを特徴とする疵検査用照明装置。

【請求項２】　帯状または板状の被検査材の表面に線状の照射パターンを形成する疵検査用照明装置において、多数の光ファイバが光ファイバの光軸に対して垂直方向に整列する複数の光ファイバ束からなり、光ファイバ束が前記整列方向に沿って並ぶように接合された光ファイバユニットと、円柱レンズからなる複数の集光レンズが前記光ファイバの整列方向に沿って並ぶように接合された集光ユニットとを備え、前記光ファイバ束の側端部に対向する前記集光レンズの直径が中央部の集光レンズの直径より大きいことを特徴とする疵検査用照明装置。

【請求項３】　帯状または板状の被検査材の表面に線状の照射パターンを形成する疵検査用照明装置において、多数の光ファイバが光ファイバの光軸に対して垂直方向に整列する複数の光ファイバ束からなり、光ファイバ束が前記整列方向に沿って並ぶように接合された光ファイバユニットと、円柱レンズからなる複数の集光レンズが前記光ファイバの整列方向に沿って並ぶように接合された集光ユニットとを備え、前記光ファイバ束の側端部の光ファイバ径が中央部の光ファイバ径よりも大きいことを特徴とする疵検査用照明装置。

【請求項４】　光ファイバが複数段に積み重ねられた前記光ファイバユニットを、剛性を有する上板および下板で挟み込んだ請求項１、２、または３記載の疵検査用照明装置。

【請求項５】　光ファイバが１本ずつ挿入される多数の平行な案内溝が、前記下板に設けられている請求項４記載の疵検査用照明装置。

【請求項６】　前記光ファイバユニットの撓みに合わせて前記集光ユニットを撓わませている請求項１、２または３記載の疵検査用照明装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】この発明は疵検査用照明装置、特に帯状または板状の被検査材の表面を照明して疵を光学的に検査する疵検査用照明装置に関する。

【０００２】

【従来の技術】帯状または板材の疵検査装置の一つとして、光学式疵検査装置がある。光学式疵検査装置は、被検査材の表面に線状の照明パターンを形成する照明装置を備えている。例えば、鋼板を長手方向に送りながら鋼板表面に線状の照明パターンを形成して、検査作業者が鋼板表面を直接目視して、またはモニタ画面上で疵を検査する。

【０００３】従来、蛍光灯を代表とする照明装置の棒状光源は、光量、集光性においてきわめて不十分であった。その上、被検査材との距離が取れないばかりか、温度変化に弱く、指向性がなく、長尺（例えば２ｍ）の棒状光源を構成することは困難であり、高速ラインへの適用や、撮像分解能を上げることができなかった。このような問題を解決する照明装置として、光ファイバ照明が期待され、様々な光ファイバ照明装置が開発されている。

【０００４】光ファイバ照明装置は、光源と、多数の光ファイバ整列するシート状の光ファイバ束と、帯状または板状の被検査材の表面に線状の照射パターンを形成する集光レンズとからなっている。従来の光ファイバ照明装置は、市販の光ファイバ束と集光レンズ（円柱レンズ）とを組み合わせたものであるが、次のような問題があった。

【０００５】被検査材の幅に合わせて幅方向（光ファイバ光軸に垂直方向）に長く整列する光ファイバ束を必要とするため、幅５００㎜程度の光ファイバ束２４の数個を幅方向に接合していた。この接合部で照度が劣化していた。光ファイバ束２４の両端部で、図１１に示すように光ファイバ２６が必ずしも規則正しく整列されていないために照度劣化を招いていた。また、集光レンズも長さに制限があり、複数の集光円柱レンズを紫外線硬化樹脂などで接合していたが、接合部で照度劣化が生じていた。また、光ファイバ束では光ファイバが複数段積み重ねられているが、図１２および図１３に示すように光ファイバユニット２１保持する上板５５および下板５６が撓むため１００μｍ程度のオーダーで光ファイバ束２２の中央部が凹んだり、膨れ上がったりする。これら凹みや膨れのために、照明光の光線が不揃いとなる。集光レンズ４０と被検査材との距離は数ｍ程度になると、図１４に示すように被検査材では数㎜程度のオーダーで不揃いとなる。この結果、被検査材表面での照度が不均一となり、疵検出能が低下していた。

【０００６】なお、棒状光源を用いた照明装置として、例えば特開２０００－６５７５５号公報で開示された表面検査装置がある。光ファイバ束と集光レンズとを備えた照明装置として、例えば特開２０００－１４９６０７号公報で開示された照明装置がある。

【０００７】

【発明が解決しようとする課題】この発明の課題は、被検査材表面を均一に照射し、高い疵検出能により疵を検出することができる疵検査用照明装置を提供することで

ある。

【０００８】

【課題を解決するための手段】第１発明の疵検査用照明装置は、帯状または板状の被検査材の表面に線状の照射パターンを形成する疵検査用照明装置において、多数の光ファイバが光ファイバの光軸に対して垂直方向に整列する複数の光ファイバ束からなり、光ファイバ束が前記整列方向に沿って並ぶように接合された光ファイバユニットと、円柱レンズからなる複数の集光レンズが前記光ファイバの整列方向に沿って並ぶように接合された集光ユニットとを備えている。そして、前記光ファイバ束の接合部に対し集光レンズの接合部が前記光ファイバの整列方向にずれるようにして集光ユニットが前記光ファイバユニットの出射側に配置されている。

【０００９】上記疵検査用照明装置において、集光レンズの接合部は、光ファイバ束の接合部に対し光ファイバの整列方向（横方向）にずれるように位置している。したがって、光ファイバ束の接合部と集光レンズの接合部との重なりによる照度低下は生じない。

【００１０】第２発明の疵検査用照明装置は、帯状または板状の被検査材の表面に線状の照射パターンを形成する疵検査用照明装置において、多数の光ファイバが光ファイバの光軸に対して垂直方向に整列する複数の光ファイバ束からなり、光ファイバ束が前記整列方向に沿って並ぶように接合された光ファイバユニットと、円柱レンズからなる複数の集光レンズが前記光ファイバの整列方向に沿って並ぶように接合された集光ユニットとを備えている。そして、前記光ファイバ束の側端部に対向する前記集光レンズの直径が中央部の集光レンズの直径より大きくなっている。

【００１１】上記疵検査用照明装置において、光ファイバ束の側端部から光線が広がるように出射される場合、前記大径の集光レンズは広がった光線を被検査材表面に集めることとができ、照度低下を防ぐことができる。

【００１２】第３発明の疵検査用照明装置は、帯状または板状の被検査材の表面に線状の照射パターンを形成する疵検査用照明装置において、多数の光ファイバが光ファイバの光軸に対して垂直方向に整列する複数の光ファイバ束からなり、光ファイバ束が前記整列方向に沿って並ぶように接合された光ファイバユニットと、円柱レンズからなる複数の集光レンズを前記光ファイバの整列方向に沿って並ぶように接合された集光ユニットとを備えている。そして、前記光ファイバ束の側端部の光ファイバ径が中央部の光ファイバ径よりも大きくなっている。

【００１３】光ファイバ径が大きいと光ファイバの出口側から照射される光量が多いため多少の光ファイバの不揃いが生じていても、当該不揃いに起因する照度低下を防止することができる。

【００１４】上記第１、２および３の発明において、前記光ファイバユニットで複数段に積み重ねられた光ファイバを、剛性を有する上板および下板で挟み込むことが好ましい。剛性を有する上板および下板による挟込みにより光ファイバユニットの撓みが矯正されるので、被検査材上に直線状の照明パターンが形成される。光ファイバが１本ずつ挿入される多数の平行な案内溝を前記下板に設けることが好ましい。最下段の光ファイバは案内溝に沿って整列し、上段の光ファイバは最下段の光ファイバに沿って順次整列するので、光ファイバが不揃いとなることはない。

【００１５】また、上記第１、２および３の発明において、前記光ファイバユニットの撓みに合わせて前記集光ユニットを撓ませるようにしてもよい。集光レンズの撓みを調整することにより、光ファイバ束からの不揃いの光線を平行に整列することができる。

【００１６】

【発明の実施の形態】図１、図２および図３は、第１発明の照明装置を模式的に示している。照明装置は、主として光源、ライトガイド部、および集光部からなっている。

【００１７】光源１０は、高輝度点光源１２と凹面鏡１４とを備えている。高輝度点光源１２として例えばメタルハライドランプ、ハロゲンランプ、キセノンランプなどが用いられる。凹面鏡１４として楕円面鏡、または放物面鏡が適している。

【００１８】ライトガイド部２０は、光源１０から光ファイバユニット２１まで延びる光ファイバケーブル２９を備えている。光ファイバケーブル２９は、多数の光ファイバ２６が束ねられ、プラスチックシースで被覆されている。光ファイバユニット２１の内部において、光ファイバ２６は光ファイバケーブル２９の先端部から分岐整列して光ファイバ束２２（図３に示す）を構成する。光ファイバ束２２は多数の光ファイバ２６を光軸に対し垂直方向（横方向）に整列し、複数段積み重ねられて構成されている。横方向に隣り合う光ファイバ束２２どうしは、側端部が被検査材１の幅に合わせて接着剤でつなぎ合わされ、横方向に延びる帯状となっている。光ファイバユニット２１は、上板３１と下板３２との間に挟まれて光ファイバ保持フレーム３０に保持されている。

【００１９】集光部４０は、複数の集光レンズ４２からなる集光ユニット４１を備えている。集光レンズ４２として円柱レンズが用いられる。横方向に隣り合う集光レンズ４２どうしは、側端部が光ファイバ束２２と同様に接着剤でつなぎ合わされて横方向に細長となっている。集光レンズ４２の接合部４３は、光ファイバ束２２の接合部２３に対し横方向にずれるように位置している。このずれは、各光ファイバの中間部にレンズの接合部が位置するようにする。したがって、光ファイバ束２２の接合部２３と集光レンズ４２の接合部４３との重なりによる照度低下は生じない。

【００２０】上記のように構成された装置において、高

輝度点光源１２からの照明光は凹面鏡１４で光ファイバケーブル２９の入射端に集光される。照明光は、光ファイバケーブル２９を介して光ファイバユニット２１に導かれる。光ファイバユニット２１を通って出射した照明光は、集光レンズ４２で集光されて被検査体表面１に線状の照明パターン５を形成する。被検査体１はこれの長手方向Sに移動しており、疵Ｆはリニアアレイカメラ６０で撮像される。疵Ｆはモニタ(図示しない)の画面で目視により、または映像信号を画像処理して検出される。光ファイバ束２２の接合部２３と集光レンズ４２の接合部４３との重なりによる照度低下は生じない。このために、被検査材表面を均一に照射し、高い疵検出能により疵を検出することができる。

【００２１】図４および図５は、第２発明の照明装置を示している。図１に示す部材と同様の部材には同一の参照符号を付け、その詳細な説明は省略する。集光ユニット４５は、標準集光レンズ４７および大径集光レンズ４８とからなっている。大径集光レンズ４８の直径は標準集光レンズ４７の直径の１．５～２．０倍程度とし、レンズ材質をｎｄ＝１．８～１．９とすることによって、焦点距離は標準集光レンズ４７の焦点距離と等しくなっている。ここで、ｎｄとはヘリウムランプから発せられる光（波長は５８７．６［nm］である）を用いて屈折率を計測した場合の屈折率を示す。大径集光レンズ４８は、光ファイバ束２２の接合部２３に対向する位置にある。前述のように、実際の光ファイバ束２４は図１１に示すように側端部の光ファイバ２６は整列していない。このために、光ファイバユニット２１からの光線は広がるように出射されるので、被検査材では照度が低下する。上記大径集光レンズ４８は、光ファイバ束２４の側端部で広がった光線を被検査材表面に集めることとができ、照度低下を防ぐことができる。

【００２２】図６は、第３発明の照明装置を示している。図１に示す部材と同様の部材には同一の参照符号を付け、その詳細な説明は省略する。光ファイバ束２５の両側端部では、標準径の光ファイバ２６（中央部の光ファイバ）と標準径より大きい大径光ファイバ２７とが組み合わされている。図１１のように光ファイバ束２５の側端部で光ファイバ２６の列が乱れると照度低下を招くが、図６に示す装置では光ファイバ２７の直径が大きいので、光ファイバの出口側から照射される光量が多いため多少の光ファイバの不揃いが生じていても、当該不揃いに起因する照度低下を防止することができる。側端部の幅は光ファイバ束２５の全幅の１０～２０％程度、したがって中央部の幅は６０～８０％である。側端部の光ファイバ２７の直径は、中央部の標準光ファイバ２６の直径の例えば２～３倍程度である。側端部の光ファイバを大径光ファイバのみとしてもよく、また側端部から中央部に向かうに従い段階的に光ファイバ径を小さくするようにしてもよい。

【００２３】図７は、照明装置の他の実施の形態を示している。光ファイバユニット２１は、光ファイバ保持フレーム３０内で剛性を有する上板３１と下板３２との間で保持されている。光ファイバ保持フレーム３０のめねじ部３６に調節ねじ３７がはめ合っており、調節ねじ３７の先端は上板３１と下板３２にそれぞれ押し当てられている。調節ねじ３７は光ファイバユニット３１の撓みに応じて締め付けられ、光ファイバユニット２１の撓みを矯正するので、被検査材上に直線状の照明パターンが形成される。

【００２４】図８は、照明装置の更に他の形態を示している。この照明装置では、前記光ファイバ保持フレームの下板３３に光ファイバの光軸方向に沿って平行な半円状案内溝３４が設けられている。案内溝３４の直径は、１００～３００μm程度である。案内溝３４に光ファイバが１本ずつ挿入され、その上に２段目からの光ファイバ２６は、積み重ねられる。図９に示すように、上段の光ファイバ２６は下段の隣り合う光ファイバ２６の間に配置される。光ファイバ２６は最下段の光ファイバ２６に沿って整列するので、光ファイバ束２２の側端部で光ファイバ２６が不揃いとなることはない。

【００２５】図１０は、照明装置の更に他の実施の形態を示している。図１０(a) に示すように、集光ユニット４９はレンズ保持フレーム５０に保持されている。レンズ保持フレーム５０に取り付けられたナット５１に調節ねじ５２がはめ合っている。調節ねじ５２の先端部は集光レンズ４９に押し当てられており、調節ねじ５２により集光レンズ４９の撓みを光ファイバ束の撓みに合わせる。集光レンズの撓みを調整することにより、光ファイバ束からの不揃いの光線を平行に整列することができる。図１０(b) は被検査材表面上の照明パターンを示しており、集光レンズ４９の撓みを調節することにより湾曲した光線軌跡８を規範直線７に修正することができる。

【００２６】

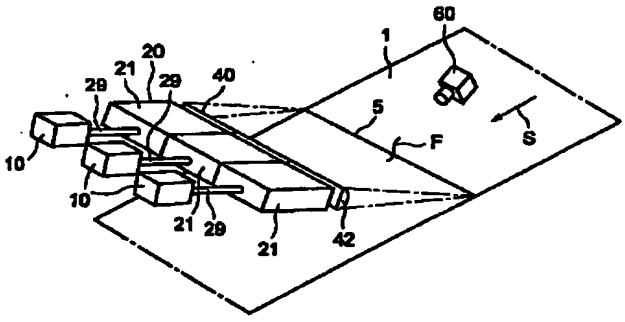
【発明の効果】第１発明の疵検査用照明装置では、集光レンズの接合部は光ファイバ束の接合部に対し横方向にずれるように位置しているので、光ファイバ束の接合部と集光レンズの接合部との重なりによる照度低下は生じない。第２発明の疵検査用照明装置では光ファイバ束の両端部の集光レンズ径が中央部の集光レンズ径より大きく、また第３発明の疵検査用照明装置では光ファイバ束の両端部の光ファイバ径が中央部の光ファイバ径よりも大きいので、光ファイバ束の側端部における光線の不揃いを防ぐことができる。これらの結果、被検査材表面は均一に照射され、高い疵検出能により疵を検出することができる。

【図面の簡単な説明】

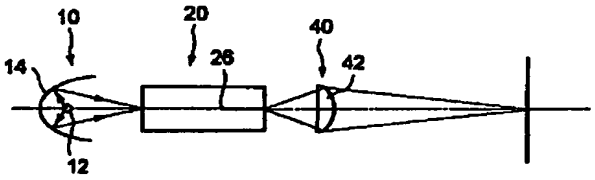
【図１】第１発明の実施の形態である疵検査用照明装置を模式的に示す斜視図である。

【図２】図１に示す照明装置の光学系を模式的に示す側面図である。
【図３】図３(a) は図１に示す装置の正面図であり、(b) は平面図である。
【図４】第２発明の実施の形態である疵検査用照明装置を示しており、図３(a) は正面図であり、(b) は平面図である。
【図５】図４に示す装置の集光ユニットの側面図である。
【図６】第３発明の実施の形態であり、光ファイバ束の正面図である。
【図７】この発明の実施の他の形態である疵検査用照明装置を示す正面図である。
【図８】図７に示す装置に用いられる下板の一部を示す斜視図である。
【図９】図８に示す装置に保持された光ファイバ束の正面図である。
【図１０】この発明の実施の更に他の形態である疵検査用照明装置を示しており、図１０(a) は正面図であり、(b) は照明パターンの模式図である。
【図１１】光ファイバ束の側端部における光ファイバの不揃いを模式的に示す平面図である。
【図１２】従来の疵検査用照明装置の１例を模式的に示す正面図である。
【図１３】図１２に示す光ファイバ束の拡大図である
【図１４】照明の光線の不揃いを説明する図面である。
【符号の説明】
１　被検査材
５　照明パターン
＊７　規範直線
８　光線軌跡
１０　光源
１２　高輝度点光源
１４　凹面鏡
２０　ライトガイド部
２１　光ファイバユニット
２２,２５　光ファイバ束
２３　接合部
２６,２７　光ファイバ
３０　光ファイバ保持フレーム
３１　上板
３２　下板
３３　下板
３４　案内溝
３７　調節ねじ
４０　集光部
４１　集光ユニット
４２　集光レンズ
４３　接合部
４７　標準集光レンズ
４８　大径集光レンズ
４９　集光レンズ
５０　集光レンズ保持フレーム
５１　ナット
５２　調節ねじ
５６　上板
５７　下板
＊　Ｆ　疵

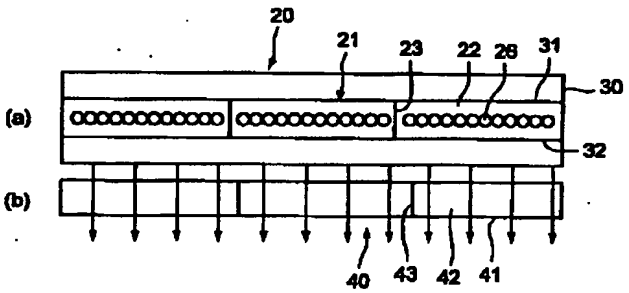
【図１】



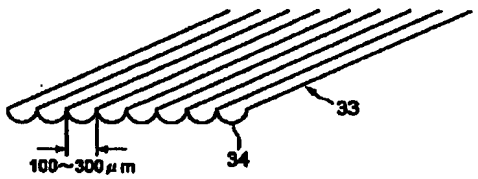
【図２】



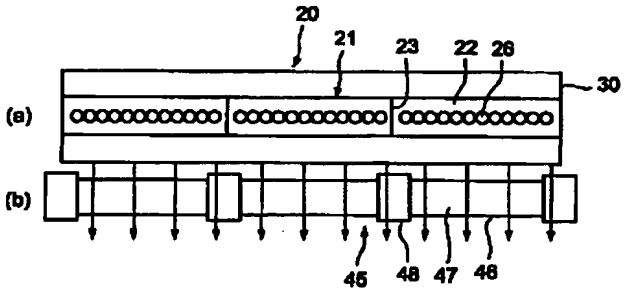
【図３】



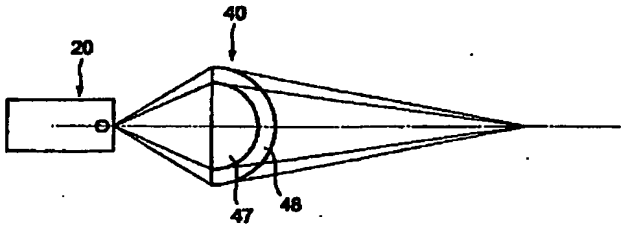
【図８】



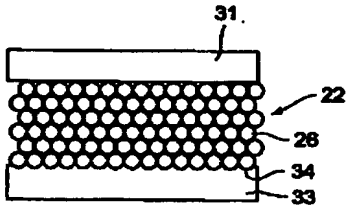
【図４】



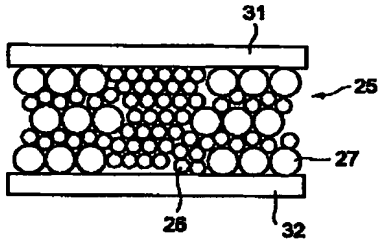
【図５】



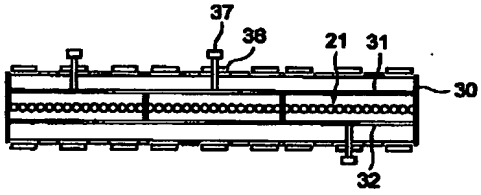
【図９】



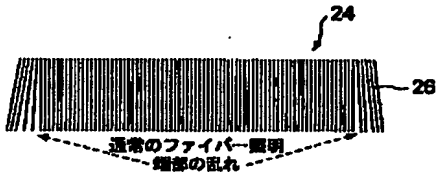
【図６】



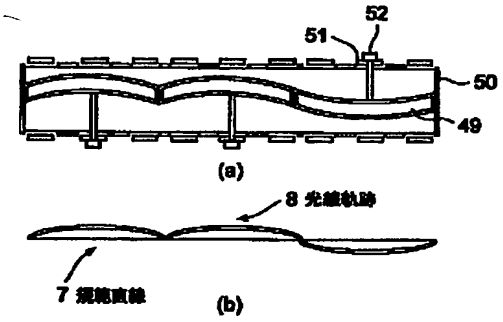
【図７】



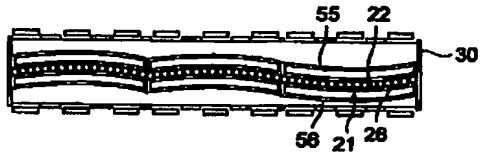
【図１１】



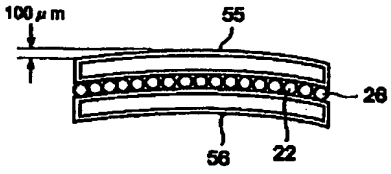
【図１０】



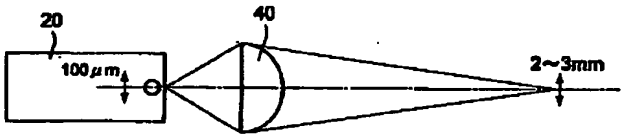
【図１２】



【図１３】



【図１４】



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